INDEXING POPULATION DENSITIES OF THE CARDINAL WITH TAPE-RECORDED SONG

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In studying habitat utilization by the Cardinal (*Richmondena cardinalis*), I required information about the relative densities of populations in different regions. As indexing population densities was not a primary objective, I sought a rapid method that would yield consistent and comparable results.

Many standard techniques of measuring population density (e.g., Kendeigh, 1944) were impracticable in my large study areas (15 by 15 miles). Roadside counts (Kendeigh, 1944; Howell, 1951; Hewitt, 1963) did not appear promising as Cardinals are seldom seen along roadways in southern Ontario where I began this work. Since the Cardinal is a loud singer and is netted easily using a recorded song and a mounted bird as a lure, I developed a modified roadside count method utilizing responses to tape-recorded song.

Listening counts along roadways are well known to workers in gamebird management (Kimball, 1949; Rosene, 1957; Foote, et al., 1958; Smith and Gallizioli, 1965; Gates, 1966). Tape-recordings have been used to locate birds (Bohl, 1956; Levy, et al., 1966). In census methods, Stirling and Bendell (1966) used tape-recorded female calls to stimulate calling of the Blue Grouse (*Dendragapus obscurus*), and Giltz (1967) used recorded alarm cries of young Red-winged Blackbirds (*Agelaius phoeniceus*) to stimulate flight of adults.

BASIC TECHNIQUE

An automobile is driven to a predetermined point on a road, and three amplified tape-recorded Cardinal songs are played in 15 seconds. An observation period of 30 seconds follows when the number of responding birds are counted. The procedure is conducted four times, bringing the total observation time to two minutes. A "response" is defined as the singing of a Cardinal or the approach of a non-singing male. About 20 points could be sampled in two to three hours if the points were selected at random from a grid of one-mile cells, represented about 60 per cent of the total study area, and were sampled via the shortest connecting route. In other applications when sample points were non-random, e.g., a line transect with points one mile apart, sampling was somewhat faster, and about 10 points could be sampled per hour. The index value is the average number of Cardinals responding at the sampled points.

Songs were broadcast from a continuous loop of tape and fed through a 12 watt transistorized amplifier and a 7.5 watt loud speaker fitted with a horizontal, circular baffle and mounted vertically on a car window. The baffle and vertical mounting were

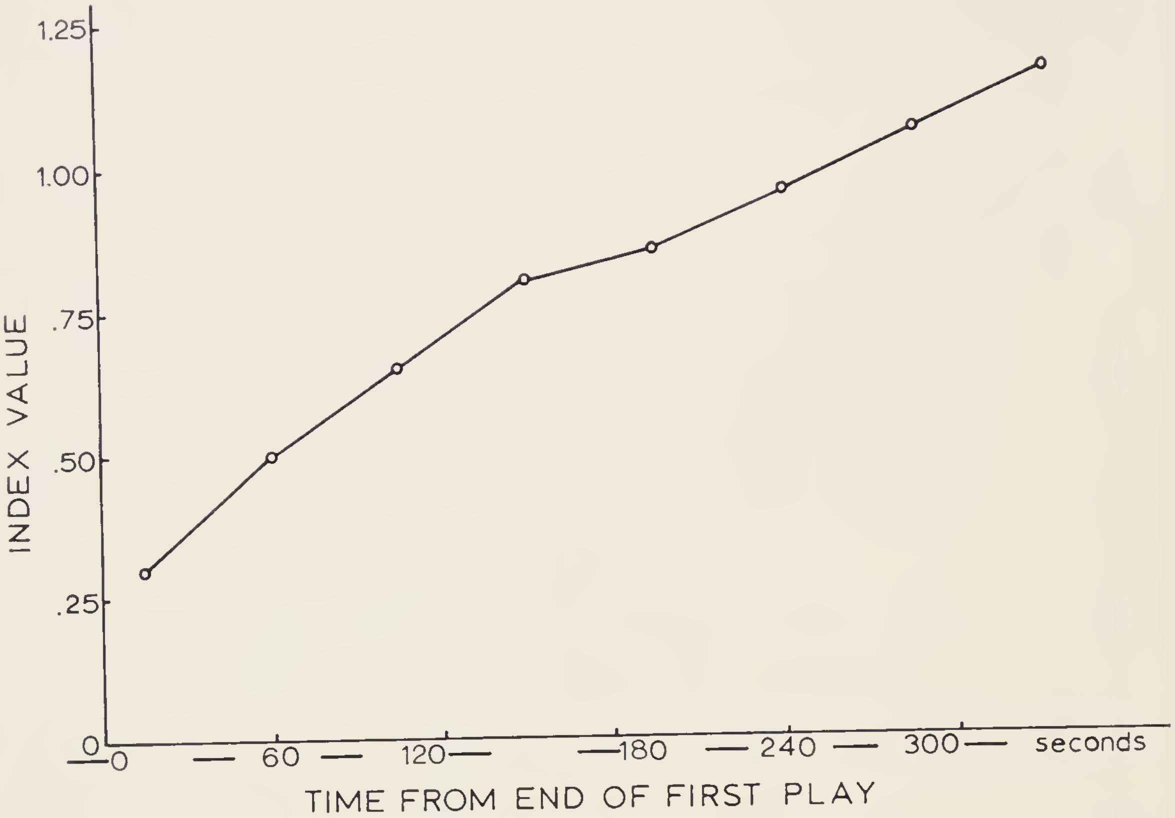

FIG. 1. Cumulative increase in index value with extended observation periods. Plotted points represent the average of 20 points sampled shortly after sunrise on 27 and 28 March 1966 near Lambeth, Ontario. Solid lines on time scale indicate playing of tape-recorded song.

used to distribute the sound as uniformly as possible. A meter, connected across the voice coil, monitored the output level of the signal. The volume level used was empirically determined as that which a listener could just hear at one-quarter mile, approximately the average maximum distance that a singing Cardinal can be heard.

Urban areas and heavily travelled paved roads were avoided because of the noise usually associated with them.

INCREASE IN RESPONSE OVER NORMAL SINGING

Figure 1 shows the effect of continuing observation periods beyond the four normally used. The cumulative increase in index value shows almost no levelling off even by the eighth period. My selection of four observation periods is, therefore, arbitrary and results in a conservative index value: it is a compromise between a large number of observation periods and the maximum number of points that can be sampled in a reasonably short time.

There is no doubt that the use of tape-recordings increases the number of birds heard or seen (Table 1). The difference in percentage increase between April and July is typical; the spontaneous singing of the species is decreasing throughout this period while the responses to recordings remain about the same.

Table 1

Increase in Response Attributable to the Use of Tape-Recordings†

Locality (Nearest town)	Sampling dates	Index value		Percentage increase	No. of points sampled	P*
		Without tape	With tape			
Lambeth, Ontario	18–19 April	0.600	1.000	67	20	NS
Melbourne, Ontario	21–22 July	0.290	0.613	111	31	< 0.025
Melbourne, Ontario	15–16 July**	0.161	0.419	160	31	< 0.01
Dresden, Tennessee	22–23 June	2.95	4.05	37	20	< 0.005

† In all additional comparisons, the number of Cardinals responding to tape-recordings was always greater than the number noted without recordings.
* Significance level of one-tailed Wilcoxon Signed Rank Test of difference between dependent means (Siegel, 1956).
** Sampled between 10:30 and 13:30 hours. All others were sampled just after sunrise.

FACTORS INFLUENCING RESPONSE

It is important to standardize as many conditions as possible in a technique such as this. The method is not only susceptible to vagaries of weather, as are most field experiments, but to almost any distracting sound, particularly traffic and tractor noise.

The acoustic influence of topography and cover on both broadcast songs and responses presents too formidable a complex of factors for investigation here. It is assumed that such factors cancel each other over a large area. Also, they are largely mitigated in successive comparisons of the same areas.

The only main climatic factors that appear to appreciably influence responses are wind and rain. As wind increases, the observed responses decrease. Light to moderate rain seems to inhibit singing, and the drumming of rain on roads and nearby vegetation makes listening impossible. There was no evidence that even very dense fog had any influence on responses, although spontaneous singing seemed somewhat suppressed.

The distribution of responses obtained at different times of day is shown in Figure 2. The response drops from a morning peak to a low level in mid-afternoon, then rises again in the evening, but not to the same high level as morning song. This is somewhat similar to the diurnal pattern of spontaneous singing of many passerine birds (Van Tyne and Berger, 1959:147). Subsequent sampling indicated that the ratio between means of morning and evening samples was not constant enough for reliable estimation of morning

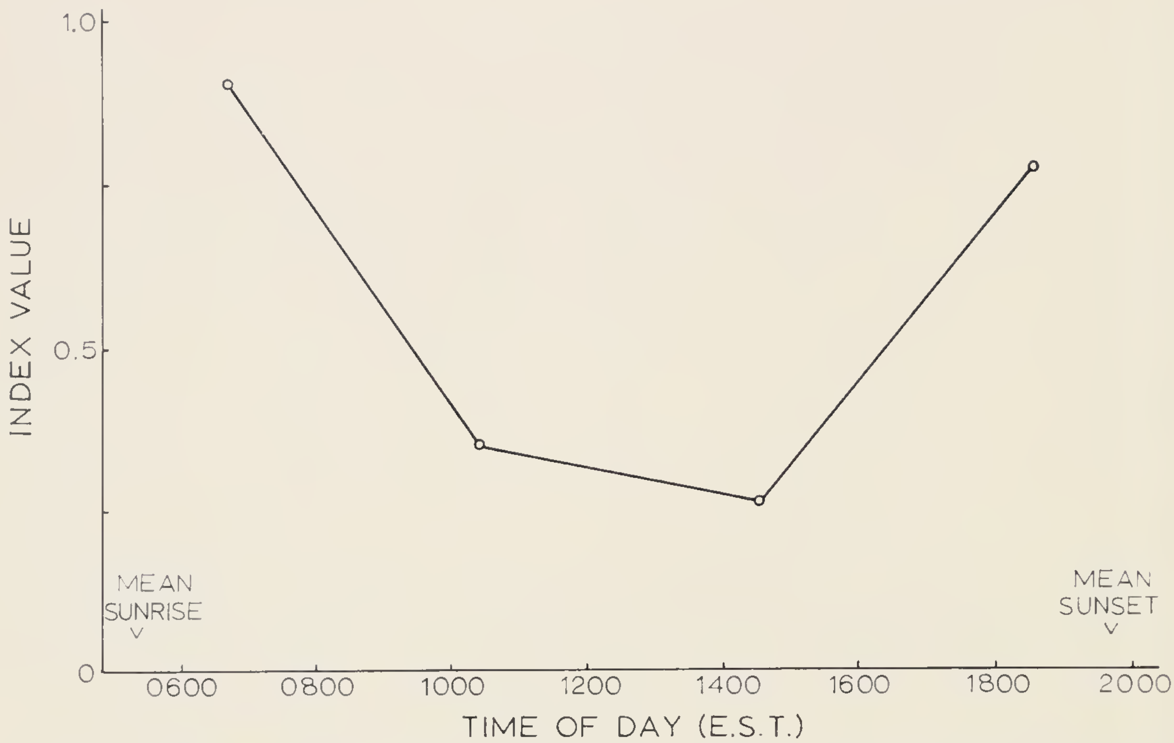

Fig. 2. Distribution of responses obtained from sampling the same 84 points at four different times of day near Melbourne, Ontario, between 2 and 13 August 1964. ($P < 0.01$ in Friedman two-way analysis of variance.)

values from adjusted evening values. This inconstancy was probably attributable to the greater chance of wind in the evening and also to an increase in human activities in some areas. Thus, all further sampling was restricted to morning hours; each sample route was begun between the onset of civil twilight and sunrise, which is about the time that this species normally begins to sing (Allard, 1930; Leopold and Eynon, 1961; Wiens, 1960).

Davis (1965) has pointed out that more singing birds may be noted at the beginning of a census period than at the end. I have found the same to be true using tape-recordings, predictable, of course, from Figure 2. But by repeating several sample routes in reverse order at the same time on different days, I discovered that although more birds are counted in the early half of sampling, the average number remains constant.

Abrupt changes in response occur in early spring at the onset of seasonal singing and again late in the summer when reproductive activity wanes. However, during the intervening period, responses remain fairly constant (Fig. 3) while spontaneous singing steadily declines. Herein lies one of the principal advantages of using tape-recordings to stimulate song since the method is not restricted to the spring when birds are most active. In Ontario, consistent results were obtained between late February and mid-August. In Tennessee, a sudden decline of spontaneous singing and con-

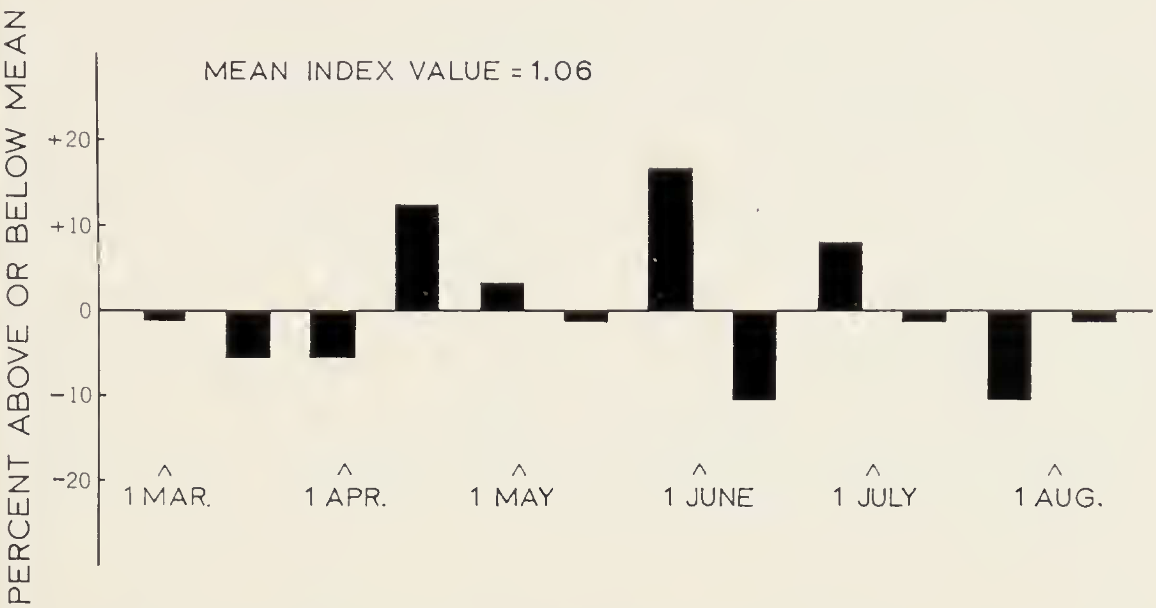

FIG. 3. Variability of index among 12 samples of the same 20 points near Lambeth, Ontario, in 1965. Points were sampled approximately every 14 days.

current reduction of response to tape-recorded song occurred in late June. However, as spontaneous singing begins somewhat earlier in the season, it is likely that the technique would also be applicable early in the year.

I did not experiment with the volume of playback song, but used a standard level previously described. The Cardinal, in Ontario, has a repertoire of some 10 to 19 song types (Lemon, 1966). I used a song that is widespread throughout the species' range; it corresponded approximately to type WBW of Lemon's classification.

A bird's reaction to a foreign conspecific song may be quite different from that to a neighbor's song (Frings, et al., 1958; Weeden and Falls, 1959). Slightly fewer Ontario birds, at the same set of 20 points, responded to songs recorded 17 miles to the west and 37 miles to the east (mean values of 0.85 versus 1.15 and 0.90 vs 1.15 respectively); whereas, slightly more Tennessee birds responded to an Ontario song recorded 627 miles NNE (Ontario, 3.65; Tennessee, 3.52). A reciprocal test in Ontario showed similar results (Ontario, 1.22; Tennessee, 1.32). This suggests that there may be slight differential response associated with different populations. However, as none of these differences are statistically significant, they appear negligible for this application. Lemon (1967) has shown different numbers of songs by Cardinals responding to different dialects, but his work shows no appreciable difference in numbers of birds responding.

Perhaps the greatest disadvantage of this, and of any technique involving listening, is its limited applicability in regions of high population density. Where large numbers of birds can be expected to respond at a point, I think

TABLE 2

COMPARISON OF RESULTS OBTAINED IN FOUR STUDY AREAS†

	Ontario			Tennessee
	Melbourne	Simcoe	Elmira	Dresden
Area (square miles)	625	625	225	225
No. of points sampled	160	160	140	140
Total birds responding	155	60	31	598
Index value*	0.97	0.38	0.22	4.3
Range of birds per point	0–4	0–2	0–2	1–8

† Areas were sampled in late April and early May from 1965 to 1967.
* A significant difference ($P < 0.001$) was found among these values using the Kruskal-Wallis one-way analysis of variance (Siegel, 1956).

that close singers tend to mask more distant ones, resulting in too few birds being scored. I believe that the low increase in Tennessee (Table 1) resulted because not all birds responding to the tape were actually counted: whereas, the fewer birds singing spontaneously had a higher probability of being noted. The bias introduced by singing females is considered to be negligible as I found during sampling that fewer than one per cent of singing Cardinals of known sex were female.

A further consideration should be kept in mind by anyone using this or any technique involving tape-recording. A recorded song or call, unless played at a volume well below the normal singing level of the species, can never be regarded as a *constant* stimulus. Birds responding to a recording probably increase the stimulus value for other conspecifics within hearing range. Consequently, in a dense population, which may only be a very local condition, a recording may have a higher effective stimulus value than in a sparse population if few birds are singing prior to the broadcast; the opposite may be true if most birds are already singing.

APPLICATIONS OF THE TECHNIQUE

The technique has proved useful in providing a relative index of abundance of the Cardinal in large study areas in different parts of its range. The recording used was obtained locally for each study area. The results are shown in Table 2. The area in Ontario with the lowest index value was selected because of its location on the periphery of the Cardinal's range; the Tennessee area was selected as probably being representative of the center of the range. A significant difference ($P < 0.001$) was found among the four indices.

Temporal changes in density can be detected similarly. I checked 20 points near Lambeth, Ontario, twice in 1965 (22 April and 31 July) and 1966 (22

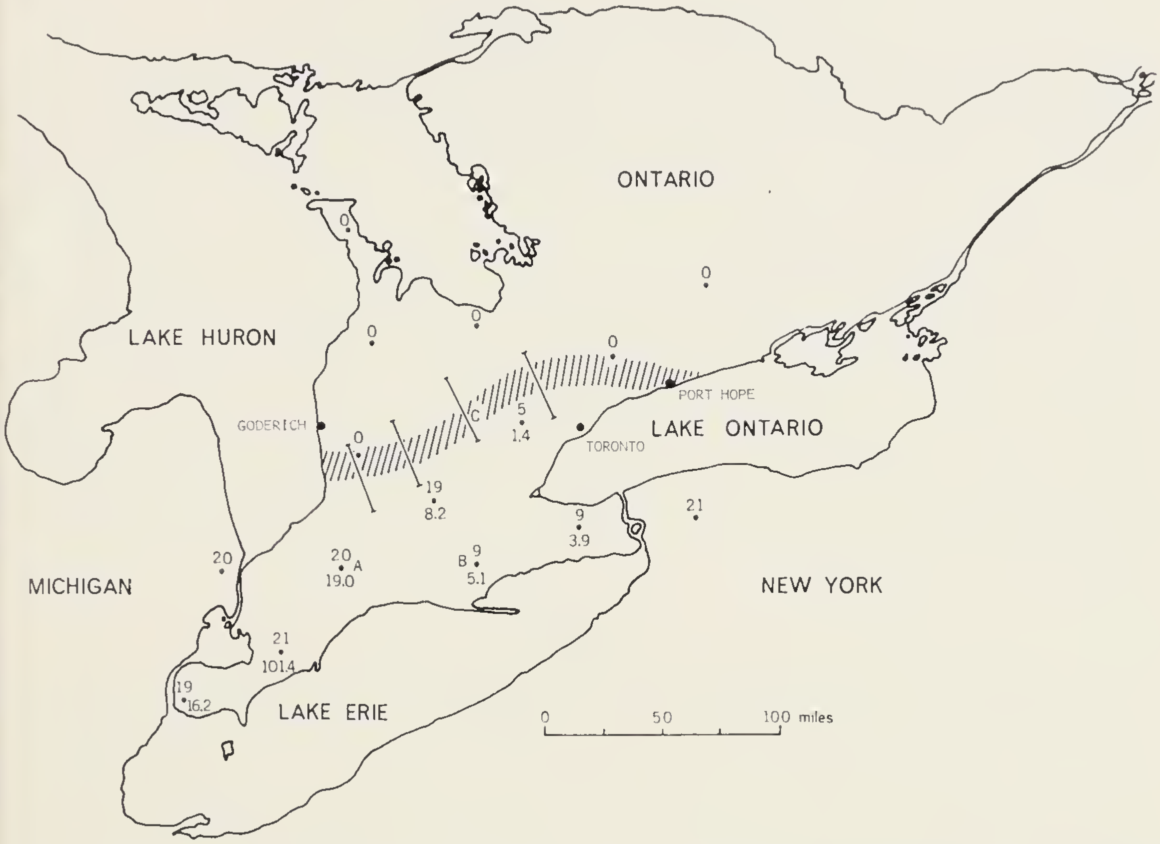

Fig. 4. Each solid circle shows the center of an area of 20 points sampled in July 1965. The total number of birds responding at these points is shown above the location. Below the location is the number of birds per 100 hectares of woody cover, where cover was measured from aerial photographs in a circle of one-quarter mile radius about each sample point. Letters A, B, and C show the approximate center of the study areas of Table 2, i.e., Melbourne, Simcoe, and Elmira respectively. The cross-hatched zone shows the edge of the Cardinal's range based on four 30-mile transects (straight lines) sampled in August 1966 in addition to the figures shown. A few small, extralimital populations are known to the north and east of this area.

March and 5 August). The two sets were averaged for each year, yielding indices of 1.02 and 1.40 respectively. The significant difference ($P < 0.05$ in Wilcoxon Signed Rank Test) suggested an increase in the population of the area.

The technique has proved very useful for obtaining information on distribution (Fig. 4). A gradient of density can be seen across southern Ontario from west to east. The difference in the index value of New York state and the adjacent regions of Ontario may result from the heavily industralized urban area along the Niagara River acting as a barrier or buffer to the recent build-up in population density in New York described by Beddall (1963). I found the edge of the range to be fairly abrupt. and not apparently correlated with type of vegetation.

RELATION OF INDEX TO POPULATION DENSITY

This technique was developed to yield a relative index, not an absolute measure of density. Because of the masking effect previously suggested in very high densities, the relationship between the index value and the real density is likely linear only in low densities. The measurement scale of the index is undoubtedly at least ordinal, i.e., an increase in index value under similar environmental conditions indicates an increase of unspecified magnitude in population density. Independent estimates of density in two of my study areas using the method of Hayne (1949) yielded 0.74 males per ha (30 per 100 acres) of undifferentiated habitat in Tennessee and 0.012 per ha (0.48 per 100 acres) in Ontario (Elmira). Of course, many more areas of different density would require sampling by the two methods to establish a continuous relationship.

SUMMARY

A roadside technique was developed for indexing population densities of the Cardinal by counting birds after the playing of a tape-recorded song. The mean number of birds responding at sample points was used as an arbitrary index. The use of tape-recordings resulted in a marked increase of birds seen and heard. Numbers of responding birds were influenced by rain, wind, and time of day. Seasonal fluctuation was relatively small, permitting the technique to be used into late summer. The method has been used to obtain indices of relative abundance in different parts of the Cardinal's range, to compare the same area for annual differences, and to delimit the range in southern Ontario. The relationship between index and actual density is virtually unknown, but is probably close to linear in low densities. Hence, the technique is better suited to moderate population densities than to very high ones. Where a rapid method of detecting differences in densities is required, the technique should work well for any species having a loud or distinctive song or call.

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